Particulate Matter (PM) Emission Factors For Processes/Equipment at Asphalt, Cement, Concrete, and Aggregate Product Plants

July 2010

This document provides emission factors for estimating **total suspended particulate matter (PM) emissions (not PM_{10})** for **individual** emission source at aggregate (sand and gravel), brick and tile, hot mix asphalt, cement, concrete batch plants. These factors are also applicable to emission sources other than processes identified in recently adopted Rules 1156 and 1157.

The factors and equations are extracted from the US EPA AP-42 document. Some of the complex equations are simplified with either default settings or assumptions that are applicable to the conditions and operations existing in the South Coast Air Basin as shown in the Reference column of the attached table. Emission factors with an asterisk (*) are not published in the EPA AP-42. These emission factors are determined using the agreed control efficiencies that were established during rule development and also are listed in the Reference column.

Facility is encouraged to apply specific parameters that are applicable to its operations to calculate emissions from the equipment/processes including the results from approved source tests and efficiencies of the add-on control equipment. Supporting documents must be submitted with the annual emission report to show the use of such parameters or source test results in calculating annual emissions.

In the absence of specific parameters and/or source tests, facility can calculate its annual emissions using the factors provided in the attached table and the following equation.

$$E = TP \times EF$$

Where: E = Emission (tons/year)

TP = Annual Throughput

EF = Emission Factor

The unit for TP in this equation must be consistent with the unit of EF. For example, if EF is in pound per ton of material transferred (lb/ton), then TP must be tons of transferred material. For unique emission sources, additional data must be used in determining the factor (EF or TP) before it can be used in emission calculation as discussed in the following notes:

Note 1: For mining/quarrying, **<u>emission factor</u>** is expressed in pound per blast (lb/blast) and is calculated as:

$$EF = 0.000014 \times A^{1.5}$$

Where: A = Total horizontal blasted area in squared foot (ft^2), provided that the blast depth is less than 70 ft.

In this case, the throughput (TP) is number of blast per year.

Note 2: For road emissions (E) caused by vehicle traffic, the **throughput** is expressed in annual vehicle miles traveled (VMT) as follows:

$$TP = VMT = \text{Road Length} \times \left(\frac{\#\,\text{Truck Trips}}{\text{Day}}\right) \times \left(\frac{\#\,\text{Days}}{\text{Year}}\right) \times \left(\frac{1\,\text{Mile}}{5{,}280\,\text{ft}}\right)$$

Where: Road Length = One-way distance in feet (ft) of paved or unpaved road within the facility, used by haul trucks and non-haul trucks.

Truck Trips = the number of roundtrips the vehicle made.

Definitions: Haul Road: an unpaved road used by haul trucks to carry materials from the quarry to the unloading/processing area within the facility.

Non-Haul Road: unpaved and/or paved road used by non-haul trucks to carry materials from one location to another location within the facility, usually between the facility's entrance/exit to loading/unloading/processing areas.

Note 3: In addition to PM emissions, VOC emissions are also expected from asphalt product during loading out and silo filling operations. **Emission factor** (lb/ton of product loaded) is expressed in as follows:

ASPHALT LOAD-OUT

$$EF_{PM} = 0.000181 + 0.00141(-V)e^{((0.0251)\times(T+460)-20.43)}$$
$$EF_{VOC} = 0.0172(-V)e^{((0.0251)\times(T+460)-20.43)}$$

SILO FILLING

$$EF_{PM} = 0.000332 + 0.00105(-V)e^{((0.0251)\times(T+460)-20.43)}$$
$$EF_{VOC} = 0.0504(-V)e^{((0.0251)\times(T+460)-20.43)}$$

Where: V = Asphalt Volatility (in negative %); (Example -2.5%)

T = Asphalt Product Mix Temperature (degree F)

Operation/Emission Sources	Emission Factor UNCONTROLLED *CONTROLLED*	Unit	References And Assumptions
ROAD EMISSIONS FROM VEHICLE TRAFFIC			
• **PAVED ROAD** $E = VMT \times k \times \left(\frac{sL}{2}\right)^a \times \left(\frac{W}{3}\right)^b$ Where: E = PM emissions (lbs) TP = VMT = annual vehicle mile traveled (see **Note 2**) $EF = k \times \left(\frac{sL}{2}\right)^a \times \left(\frac{W}{3}\right)^b$ k = particle size multiplier a, b = constants sL = road surface silt loading (g/m^2) W = average weight (tons) of the vehicle	**Aggregate / Crushed Material Plants** EF = 11.65 *EF = 2.33**	lb/VMT	Chapter 13.2.1, Equation 1 Assumptions: k = 0.082, a = 0.65, b = 1.5 Aggregate / Crushed Material sL = 53 g/m^2
	Hot Mix Asphalt Plants EF = 14.73 *EF = 2.95**	lb/VMT	Hot Mix Asphalt sL = 76 g/m^2
	Concrete Batching EF = 4.91 *EF = 0.98**	lb/VMT	Concrete Batching / Products / Others sL = 11 g/m^2 W_{Loaded} = 30 tons $W_{Unloaded}$ = 5 tons $W_{Unloaded\ for\ concrete\ Batching}$ = 12 tons Control Efficiency for chemical stabilizer = 80%
	Concrete Products/Other Plants EF = 4.19 *EF = 0.84**	lb/VMT	

Operation/Emission Sources	Emission Factor UNCONTROLLED *CONTROLLED*	Unit	References And Assumptions
• **UNPAVED ROAD** $E = VMT \times k \times \left(\frac{S}{12}\right)^a \times \left(\frac{W}{3}\right)^b$ Where: E = PM emissions (lbs) TP = VMT = annual vehicle mile traveled (see **Note 2**) $EF = k \times \left(\frac{S}{12}\right)^a \times \left(\frac{W}{3}\right)^b$ k = particle size multiplier a, b = constants S = surface material silt content (%) W = average weight (tons) of the vehicle	**Aggregate Plants** HAUL VEHICLE EF = 16.36 *EF = 3.27** NON-HAUL VEHICLE EF = 8.79 *EF = 1.76** **Other Plant** HAUL VEHICLE EF = 14.66 *EF = 2.93** NON-HAUL VEHICLE EF = 5.26 *EF =1.05**	lb/VMT lb/VMT lb/VMT lb/VMT	Chapter 13.2.2, Equation (1a) Assumptions: k = 4.9, a = 0.7, b = 0.45 HAUL W_{Loaded} = 120 tons $W_{Unloaded}$ = 45 tons $S_{Aggregate}$ = 8.3% S_{Others} = 7.1% NON-HAUL W_{Loaded} = 30 tons $W_{Unloaded}$ = 5 tons $S_{Aggregate}$ = 10% S_{Others} = 4.8 % Control Efficiency for chemical stabilizer = 80%
OPEN STORAGE PILE TP = annual tonnage of stored material = amount of material loaded into, minus the amount of material removed from the pile	EF = 0.33 *EF = 0.0165**	lb/ton	Emission Factor Documentation for AP-42 Section 11.19.1, Final Report, Table 4-1 Control Efficiency = 95%

Operation/Emission Sources	Emission Factor UNCONTROLLED *CONTROLLED*	Unit	References And Assumptions
MINING/QUARRYING			
• **DRILLING** TP = number of hole drilled	EF = 1.3	lb/hole	Chapter 11.9, Table 11.9-4
• **BLASTING** (see **Note 1**) TP = number of blast	EF = 0.000014 (A) $^{1.5}$	lb/blast	Chapter 11.9, Table 11.9-1
LOADING/UNLOADING/CONVEYOR TRANSFER POINT For a system of multiple transfer points, this EF must be multiplied by the number of transfer points (where materials drop from one point to another). Refer to Rule 1157 definition for more detail.	**Aggregate/Crushed Miscellaneous Base/ Asphalt Plants** EF = 0.003 *EF = 0.00015**	lb/ton	Chapter 11.19.2, Table 11.19.2-2 Control Efficiency = 95%
	Concrete Batching and Others SAND: EF = 0.0021 *EF = 0.00011**	lb/ton	Chapter 11.12, Table 11.12-2 Control Efficiency = 95%
	AGGREGATE: EF = 0.0069 *EF = 0.00035**	lb/ton	

Operation/Emission Sources	Emission Factor UNCONTROLLED	<u>*CONTROLLED*</u>	Unit	References And Assumptions
• **WEIGHT HOPPER / SURGE BIN**	Concrete Batching EF = 0.0051	<u>*EF = 0.00026**</u>	lb/ton	Chapter 11.12, Table 11.12-2 Control Efficiency = 95%
	Aggregate and Others EF = 0.003	<u>*EF = 0.00015**</u>	lb/ton	
• **SILOS** Cement	EF = 0.72	<u>*EF = 0.00099*</u>	lb/ton	Chapter 11.12, Table 11.12-2
Cement Supplements (Fly Ash)	EF = 3.14	<u>*EF = 0.0089*</u>	lb/ton	
• **CONCRETE LOADING (Truck Mix)**	EF = 0.995	<u>*EF = 0.0568*</u>	lb/ton	Chapter 11.12, Table 11.12-2
• **CONCRETE LOADING (Central Mix)**	EF = 0.544	<u>*EF = 0.0173*</u>	lb/ton	Chapter 11.12, Table 11.12-2
• **ASPHALT PRODUCTS LOAD OUT (**see **Note 3)**		**PM:** <u>*EF = 0.00052*</u>	lb/ton	Chapter 11.1, Table 11.1-14
		VOC: <u>*EF = 0.0042*</u>	lb/ton	V=-0.5, T=325 ^{o}F
• **ASPHALT SILO FILLING (**see **Note 3)**		**PM:** <u>*EF = 0.00059*</u>	lb/ton	Chapter 11.1, Table 11.1-14
		VOC: <u>*EF = 0.0122*</u>	lb/ton	V=-0.5, T=325 ^{o}F

Operation/Emission Sources	Emission Factor UNCONTROLLED	 *CONTROLLED*	Unit	References And Assumptions
CRUSHING				
• **PRIMARY CRUSHER**	EF = 0.014*	*EF = 0.00031*	lb/ton	Chapter 11.6, Table 11.6-4
• **TERTIARY CRUSHER**	EF = 0.0054	*Water: EF = 0.00027**	lb/ton	Chapter 11.19.2, Table 11.19.2-2
		*Baghouse: EF = 0.00005**	lb/ton	Control Efficiency (Water) = 95%
		*Default: EF = 0.00012**	lb/ton	Control Efficiency (Baghouse) = 99%
• **FINE CRUSHER**	EF = 0.039	*Water: EF = 0.00195**	lb/ton	Chapter 11.19.2, Table 11.19.2-2
		*Baghouse: EF = 0.00039**	lb/ton	Control Efficiency (Water) = 95%
		*Default: EF = 0.00086**	lb/ton	Control Efficiency (Baghouse) = 99%
				All Control Efficiency (default) = 97.8%

Operation/Emission Sources	Emission Factor UNCONTROLLED	 *CONTROLLED*	Unit	References And Assumptions
SCREENING				
• **COARSE** Aggregate/Crushed Misc. Base/ Hot Mix Asphalt	EF = 0.025	*Water: EF = 0.00125** *Baghouse: EF = 0.00025** *Default: EF = 0.00098**	lb/ton lb/ton lb/ton	Chapter 11.19.2, Table 11.19.2-2 Control Efficiency (Water) = 95% Control Efficiency (Baghouse) = 99%
• **FINE**	EF = 0.30	*Water: EF = 0.015** *Baghouse: EF = 0.003** *Default: EF = 0.0117**	lb/ton lb/ton lb/ton	Chapter 11.19.2, Table 11.19.2-2 Control Efficiency (Water) = 95% Control Efficiency (Baghouse) = 99%
• **SAND**	EF = 0.21*	*EF = 0.0083*	lb/ton	Chapter 11.19.1, Table 11.19.1-1
GRINDING AND SCREENING				
• **CONCRETE PRODUCTS**	EF = 8.5	*Water: EF = 0.425** *Baghouse: EF = 0.085** *Default: EF = 0.3315**	lb/ton lb/ton lb/ton	Chapter 11.3, Table 11.3.2 Control Efficiency (Water) = 95% Control Efficiency (Baghouse) = 99% All Control Efficiency (default) = 96.1%

Operation/Emission Sources	Emission Factor		Unit	References And Assumptions
	UNCONTROLLED	*CONTROLLED*		
CEMENT MILLING				
Raw Mill	EF = 1.2*	*EF = 0.012*	lb/ton	Chapter 11.6, Table 11.6-4
Finish Grinding Mill	EF = 0.8*	*EF = 0.008*	lb/ton	Control Efficiency = 99%
OTHER PROCESS/EQUIPMENT				
• **DRYER/HOT SCREENS/MIXERS**				
SAND and GRAVEL	EF = 2.0	*EF = 0.039*	lb/ton	Chapter 11.19.1, Table 11.19.1-1
BATCH MIX ASPHALT	EF = 32	*EF = 0.042*	lb/ton	Chapter 11.1, Table 11.1-1
DRUM MIX ASPHALT	EF = 28	*EF = 0.033*	lb/ton	Chapter 11.1, Table 11.1-3
BRICK MANUFACTURING	EF = 0.187		lb/ton	Chapter 11.3., Table 11.3-1
• **KILNS**				
BRICK	EF = 0.96		lb/ton	Chapter 11.3., Table 11.3-2
CEMENT	EF = 109*	*EF = 1.09*	lb/ton	Chapter 11.6, Table 11.6-2
CLINKER COOLER	EF = 14.7 *	*EF = 0.147*	lb/ton	Control Efficiency = 99%